CLAIMS

We claim:

1. A system comprising:

a buffer;

a wavelet transform unit having an input coupled to the buffer to perform a reversible wavelet transform on pixels stored in the buffer and to generate coefficients at an output;

a coder coupled to the wavelet transform unit to code bitplanes of wavelet transformed pixels from the wavelet transform unit and stored bitplanes of wavelet transformed pixels received from the buffer, wherein the coder comprises

a context model, and

a parallel entropy coder encoder, and

wherein the most important data is not embedded and is coded in coefficient order without buffering, a portion of less important data is buffered, embedded and written to memory in order of importance.

2. The system defined in Claim 1 wherein the buffer comprises a band buffer to store at least one band of pixels

3. The system defined in Claim 1 wherein the encoder comprises a high speed parallel coder.

4. The system defined in Claim 1 wherein the encoder comprises a QM-coder.

5. The system defined in Claim 1 where the encoder comprises a finite state machine coder.

6. The system defined in Claim 1 further comprising a coded data interface.

7. A method comprising the steps of:

dividing a coefficient into most important data and less important data;

sending the most important data to a context model for coding immediately in coefficient order;

storing the less important data and a plurality of signaling bits in memory; and

after coding most important data of all coefficients in the set of coefficients, coding the less important data and embedding by order based, in part, on the plurality of signaling bits.

8. The method defined in Claim 7 wherein the signaling bits comprise a first bit and a second bit.

9. The method defined in Claim 7 wherein a first of the signaling bits indicates if the first bit of the less important data of the coefficient is a head or tail bit, and a second of the signaling bits indicates the sign bit if the first of the signaling bits indicates that the first bit of the less important data of the coefficient is a head bit.

10. The method defined in Claim 7 wherein the signaling bits are stored adjacent to the less important data.

11. A method for coding information comprising most important data and less important data, said method comprising the steps of:

coding the most important data;

coding the position of the first bit plane in the less important data for each coefficient that is not comprised entirely of zero head bits;

coding each bit plane of less important data that does not entirely comprise of zero head bits.

12. The method defined in Claim 11 wherein the information comprises wavelet coefficients.

13. The method defined in Claim 11 wherein the step for coding the position of the first less important bit plane comprises performing a look-ahead over the entire bit planes of less important data.

14. The method defined in Claim 11 wherein the step of coding the most important data comprises the steps of:

for each tree,

coding the ss coefficient;

performing a look ahead for the most important data; and

for each non-ss coefficient,

coding a head or tail bit for each bit plane with data, and

coding a sign bit if the coefficient is not zero.

15. The method defined in Claim 14 wherein the look ahead comprises a tree look ahead, and the step of performing the look ahead comprises coding the ss-coefficients and coding the first zero bit plane with non-zero head bits for the whole tree.

16. The method defined in Claim 14 wherein the most important data is processed one wavelet tree at a time.

17. The method defined in Claim 11 wherein the lookahead

determines bit planes that comprise all zero head bits for all non-ss coefficient in the wavelet tree.

18. The method defined in Claim 17 further comprising the steps of identifying the first bit plane to code individually.

19. The method defined in Claim 18 wherein the step of identifying the first bit plane to code individually comprises indicating all non-ss coefficients of the second decomposition are zero using a first bit and indicating all non-ss coefficients of the first decomposition are zero using a second bit.

20. The method defined in Claim 11 wherein the step of coding the most important data comprises the following steps:

for each tree

coding the ss coefficient;

performing a lookahead to determine bitplanes that are all zero head bits for all non-SS coefficients in said each tree;

determining if the most important data of the entire tree is zero;

if the most important data for the entire tree is not zero then,

for all coefficients in the tree,

coding bits of the current coefficient for all

bitplanes, wherein the current coefficient is the first non-ss coefficient in the tree and starting with the first bit plane that contains data;

coding the sign bit if the current coefficient is not zero.

21. The method defined in Claim 11 wherein the step of coding the less important data comprises the steps of:

for each tree,

for each coefficient,

performing a lookahead if at the start of a lookahead interval;

coding a head or tail bit if the lookahead is not active; and

coding a sign bit if the first on bit has occurred and the lookahead is not active.

22. An apparatus for coding information comprising most important data and less important data, said apparatus comprising:

means for coding the most important data;

means for coding the position of the first bit plane in the less important data for each coefficient that is not comprised entirely of zero headbits;

means for coding each bit plane of less important data that does not

entirely comprise of zero head bits.

23. The apparatus defined in Claim 22 wherein the information comprises wavelet coefficients.

24. The apparatus defined in Claim 22 wherein the means for coding the position of the first less important bit plane comprises means for performing a look-ahead over the entire bit planes of less important data.

25. The apparatus defined in Claim 22 wherein the means for coding the most important data comprises:

means for coding the SS coefficient for each tree;

means for performing a look ahead for the most important data for each tree;

means for coding a head or tail bit for each bit plane with data for each non-SS coefficient for each tree; and

means for coding a sign bit if the coefficient is not zero for each non-SS coefficient for each tree.

26. The apparatus defined in Claim 25 wherein the look ahead comprises a tree look ahead, and the means for performing the look ahead comprises means for coding the SS-coefficients and means for coding the first zero bit plane with non-zero head bits for the whole tree.

27. The apparatus defined in Claim 25 wherein the most important data is processed one wavelet tree at a time.

28. The apparatus defined in Claim 22 wherein the means for performing the lookahead determines bit planes that comprise all zero head bits for all non-ss coefficient in the wavelet tree.

29. The apparatus defined in Claim 28 further comprising means for identifying the first bit plane to code individually.

30. The apparatus defined in Claim 29 wherein the means for identifying the first bit plane to code individually comprises means for indicating all non-ss coefficients of the second decomposition are zero using a first bit and means for indicating all non-ss coefficients of the first decomposition are zero using a second bit.

31. The apparatus defined in Claim 22 wherein the means for coding the most important data comprises:

means for coding the SS coefficient for each tree;

means for performing a lookahead to determine bitplanes that are all zero head bits for all non-SS coefficients in said each tree;

means for determining if the most important data of the entire tree is zero for each tree; and

means for coding bits of the current coefficient for all bitplanes for all coefficients in the tree if the most important data for the entire tree is not zero, wherein the current coefficient is the first non-ss coefficient in the tree and starting with the first bit plane that contains data;

means for coding the sign bit if the current coefficient is not zero for all coefficients in the tree if the most important data for the entire tree is not zero.

32. The apparatus defined in Claim 22 wherein the means for coding the less important data comprises:

means for performing a lookahead for each coefficient for each tree if at the start of a lookahead interval;

means for coding a head or tail bit for each coefficient for each tree if the lookahead is not active; and

means for coding a sign bit for each coefficient for each tree if the first on bit has occurred and the lookahead is not active.

33. A method for m-ary coding of information, said method comprising the steps of:

examining a predetermined number of coefficients;

entropy coding all of the head bits one per cycle until all head bits in the predetermined number of coefficients are coded;

coding the sign and tail bits of the predetermined number of

coefficients in the same cycle.

34. An integrated circuit (IC) chip comprising:

a pixel data interface to transfer pixel data between the IC chip and memory;

a reversible wavelet transform coupled to the pixel data interface to transfer information to and from the memory via the pixel data interface;

a context model coupled to the reversible wavelet transform to provide contexts for coding the data provided therefrom;

an encoder to encode coefficients generated by the reversible wavelet transform based on contexts provided by the context model.

35. The IC defined in Claim 34 further comprising a coefficient data interface coupled to transfer coefficients from the transform to the memory without coding.

36. The IC defined in Claim 34 wherein the coefficient data interface transfers coefficients from memory to the context model for encoding.

37. The IC defined in Claim 34 further comprising a coded data interface for providing entropy coded data to memory.

38. The IC defined in Claim 37 further comprising a decoder to decode encoded data.

39. The IC defined in Claim 36 further comprising a coded data interface to provide the decoder with entropy coded data for decoding.

40. The IC defined in Claim 34 further comprising a reversible color space converter coupled between the pixel data interface and the reversible wavelet transform to perform reversible color space conversion.

41. A method for performing compression comprising the steps of:

determining the average length of codewords to identify an encoding rate; and

adjusting a compression rate based on a desired amount of compression.

42. The method defined in Claim 41 further comprising the step of:

increasing an amount of quantization level if the encoding rate indicates compression is below a first desirable level; and

decreasing the amount of quantization if the encoding rate indicates that compression is above the second desired level.

43. The method defined in Claim 42 wherein the first and second

desirable levels are not the same.

44. The method of Claim 41 wherein the step of determining the average length of codewords is performed after bit generation.

45. The method of Claim 41 further comprising the step of signaling a new compression rate to a decoder.

46. The method of Claim 45 wherein the signaling is explicit.

47. The method of Claim 45 wherein the signaling is implicit.

48. A system comprising:

a context model;

a probability estimation machine coupled to the context model;

a bit generator coupled to the probability estimation machine; and

an encoder rate control coupled to an output of the bit generator to control the encoding rate by determining average codeword length.

49. The system defined in Claim 48 wherein an encoder rate control adjusts quantization.

50. The system defined in Claim 48 comprising a signaling block

to signal a decoder regarding a new quantization level.

51. The system defined in Claim 48 further comprising a signaling block to generate header data for a compressed data stream output of the encoder which is concatenated onto the compressed bit stream to indicate to the decoder a new level of quantization.

52. The system defined in Claim 48 wherein the encoder rate control stores an indication of the quantization level is necessary for subsequent use by the decoder.

53. An apparatus comprising the steps of:

means for dividing a coefficient into most important data and less important data;

means for sending the most important data to a context model for coding immediately in coefficient order;

means for storing the less important data and a plurality of signaling bits in memory; and

means for coding the less important data and embedding coded less important data by order based, in part, on the plurality of signaling bits after coding most important data of all coefficients in the set of coefficients.

54. The apparatus defined in Claim 53 wherein the signaling bits comprise a first bit and a second bit.

55. The apparatus defined in Claim 53 wherein a first of the signaling bits indicates if the first bit of the less important data of the coefficient is a head or tail bit, and a second of the signaling bits indicates the sign bit if the first of the signaling bits indicates that the first bit of the less important data of the coefficient is a head bit.

56. The apparatus defined in Claim 53 wherein the signaling bits are stored adjacent to the less important data.

57. An article of manufacture having at least one recordable media with executable instructions thereon which, when executed by a processing device, cause the processing device to:

divide a coefficient into most important data and less important data;

send the most important data to a context model for coding immediately in coefficient order;

store the less important data and a plurality of signaling bits in memory; and

code the less important data and embedding by order based, in part, on the plurality of signaling bits after coding most important data of all coefficients in the set of coefficients.

58. The article of manufacture defined in Claim 57 wherein the signaling bits comprise a first bit and a second bit.

59. The article of manufacture defined in Claim 57 wherein a first of the signaling bits indicates if the first bit of the less important data of the coefficient is a head or tail bit, and a second of the signaling bits indicates the sign bit if the first of the signaling bits indicates that the first bit of the less important data of the coefficient is a head bit.

60. The article of manufacture defined in Claim 57 wherein the signaling bits are stored adjacent to the less important data.

61. An article of manufacture having at least one recordable media with executable instructions thereon which, when executed by a processing device, cause the one or more processing device to:

code the most important data;

code the position of the first bit plane in the less important data for each coefficient that is not comprised entirely of zero head bits;

code each bit plane of less important data that does not entirely comprise of zero head bits.

62. The article of manufacture defined in Claim 61 wherein the information comprises wavelet coefficients.

63. The article of manufacture defined in Claim 61 further comprising instructions which, when executed by the processing device, cause processing device to perform a look-ahead over the entire bit planes of less important data.

64. The article of manufacture defined in Claim 61 further comprising instructions which, when executed by the processing device, cause processing device to:

for each tree,

code the ss coefficient;

perform a look ahead for the most important data; and

for each non-ss coefficient,

code a head or tail bit for each bit plane with data, and

code a sign bit if the coefficient is not zero.

65. The article of manufacture defined in Claim 61 wherein the look ahead comprises a tree look ahead, and the processing device performs the look ahead by coding the ss-coefficients and coding the first zero bit plane with non-zero head bits for the whole tree.

66. The article of manufacture defined in Claim 64wherein the most important data is processed one wavelet tree at a time.

67. The article of manufacture defined in Claim 61 wherein the lookahead determines bit planes that comprise all zero head bits for all non-ss coefficient in the wavelet tree.

68. The article of manufacture defined in Claim 67 further comprising the steps of identifying the first bit plane to code individually.

69. The article of manufacture defined in Claim 68 wherein the processing device identifies the first bit plane to code individually by indicating all non-ss

coefficients of the second decomposition are zero using a first bit and indicating all non-ss coefficients of the first decomposition are zero using a second bit.

70. An article of manufacture defined in Claim 61 further comprising instructions which, when executed by the processing device, cause the processing device to:

for each tree,

code the ss coefficient;

perform a lookahead to determine bitplanes that are all zero head bits for all non-SS coefficients in said each tree;

determine if the most important data of the entire tree is zero;

if the most important data for the entire tree is not zero then,

for all coefficients in the tree,

code bits of the current coefficient for all bitplanes, wherein the current coefficient is the first non-ss coefficient in the tree and starting with the first bit plane that contains data;

code the sign bit if the current coefficient is not zero.

71. The article of manufacture defined in Claim 61 further comprising instructions which, when executed by the processing device, cause the processing device to:

for each tree,

for each coefficient,

perform a lookahead if at the start of a lookahead interval;

code a head or tail bit if the lookahead is not active; and

code a sign bit if the first on bit has occurred and the lookahead is not active.

72. An article of manufacture having at least one recordable media with executable instructions thereon which, when executed by a processing device, cause the processing device to:

examine a predetermined number of coefficients;

entropy coding all of the head bits one per cycle until all head bits in the predetermined number of coefficients are coded; and

code the sign and tail bits of the predetermined number of coefficients in the same cycle.

73. An article of manufacture having at least one recordable media with executable instructions thereon which, when executed by a processing device, cause the processing device to:

determine the average length of codewords to identify an encoding rate; and

adjust a compression rate based on a desired amount of compression.

74. The article of manufacture defined in Claim 73 further comprising executable instructions on the at least one recordable media which, when executed by the processing device, cause the processing device to:

increase an amount of quantization level if the encoding rate indicates compression is below a first desirable level; and

decrease the amount of quantization if the encoding rate indicates that compression is above the second desired level.

75. The article of manufacture defined in Claim 74 wherein the first and second desirable levels are not the same.

76. The article of manufacture defined in Claim 73 wherein the processing devices determines the average length of codewords after bit generation.

77. The article of manufacture defined in Claim 73 further comprising executable instructions in the at least one recordable media, which when executed by the processing device, cause the processing device to signal a new compression rate to a decoder.

78. The article of manufacture defined in Claim 77 wherein the signaling is explicit.

79. The article of manufacture defined in Claim 77 wherein the signaling is implicit.

80. A system comprising:

modeling means for providing contexts;

probability estimating means for providing probability estimates in response to contexts from the context model;

bit generation means for providing zero or more bits in response to probability estimates from the probability estimating means; and

encoder rate control means for coupled to an output of the bit generation means for controlling the encoding rate by determining average codeword length.

81. The system defined in Claim 80 wherein an encoder rate control means adjusts quantization.

82. The system defined in Claim 80 further comprising means for signaling a decoder regarding a new quantization level.

83. The system defined in Claim 80 further comprising means for generating header data for a compressed data stream output of the encoder which is concatenated onto the compressed bit stream to indicate to the decoder a new level of quantization.

84. The system defined in Claim 80 wherein the encoder rate control means stores an indication of the quantization level is necessary for subsequent use by the decoder.

85. The method defined in Claim 34 wherein the encoder codes bit planes of wavelet transformed pixels from the reversible wavelet transform and stored bit planes of wavelet transform pixels.

86. The method defined in Claim 34 wherein the encoder codes the most important data of coefficients in a set of coefficients immediately in coefficient order and then codes the less important data and embeds the less important data by order based, in part, on a plurality of signaling bits.

87. A method comprising:

dividing a coefficient into most important data and less important data;

sending the most important data to a context model for coding immediately in coefficient order;

storing the less important data and a plurality of signaling bits in memory; and

after coding most important data of all coefficients in the set of coefficients, coding the less important data and embedding coded less important data by order based, in part, on the plurality of signaling bits.

88. The method defined in Claim 86 wherein the signaling bits comprise a first bit and a second bit.

89. The method defined in Claim 86 wherein a first of the signaling bits indicates if the first bit of the less important data of the coefficient is a head or tail bit, and a second of the signaling bits indicates the sign bit if the first of the signaling bits indicates that the first bit of the less important data of the coefficient is a head bit.

90. The method defined in Claim 34 wherein the encoder codes the most important data, then codes the position of the first bit plane in the less important data for each coefficient that is not comprised entirely of zero head bits, and then codes each bit plane of less important data that is not entirely comprised of zero head bits.

91. The method defined in Claim 34 wherein the encoder entropy codes all head bits one per cycle until all head bits in a predetermined

number of coefficients are coded and then codes sign and tail bits of the predetermined number of coefficients in the same cycle.